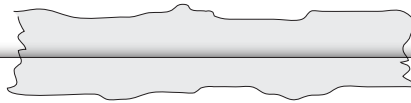


The NASA SCI Files™
The Case of the Technical Knockout

Segment 4



Trying to put the final pieces of the puzzle together, the tree house detectives dial up Dr. Sten Odenwald to learn about solar flares and coronal mass ejections and their effect on Earth. To confirm their hypothesis, the detectives send Tony to visit Joe Kunches at the National Oceanic and Atmospheric Administration (NOAA) in Boulder, Colorado, to learn more about space weather. At last the detectives think they know why their GPS receivers and radios went on the blink and had a few glitches. To wrap up the problem, they head to the airport to meet Dr. D as he returns from Norway.

Objectives

Students will

- understand how solar flares and coronal mass ejections occur.
- learn how disruptions to the ionosphere can affect radio transmissions.
- learn that space weather can affect us on Earth.
- distinguish between sunspot maximum and sunspot minimum.

Vocabulary

aurora—a faint visual phenomenon associated with geomagnetic activity, which occurs mainly in the high-latitude night sky

coronal mass ejection—billion-ton cloud of charged particles released by the Sun during large solar flare events

geomagnetic storm—a disturbance in the Earth's magnetic field associated with charged particles from solar flares and sunspot activity

ionosphere—layer of the Earth's upper atmosphere in which incoming ionizing radiation from space creates ions and free electrons that can reflect radio signals, enabling their transmissions around the world

magnetometer—a device for measuring the direction and intensity of a magnetic field

magnetosphere—the area of space around the Earth that is controlled by the Earth's magnetic field

space weather—includes all solar flares and coronal mass ejections that can cause disturbances to the ionosphere

solar cycle—the approximately 11-year variation in frequency or number of solar active events

solar flare—a brief sudden eruption of high-energy hydrogen gas from the surface of the Sun, associated with sunspots. Can cause interruptions of communication systems on Earth.

sunspot maximum—the months during the solar cycle that have the highest monthly average sunspot numbers that reach a maximum

sunspot minimum—the months during the solar cycle that have the lowest monthly average sunspot numbers that have a minimum

Video Component

Implementation Strategy

The NASA SCI Files™ is designed to enhance and enrich existing curriculum. Two to three days of class time are suggested for each segment to fully use video, resources, activities, and web site.

Before Viewing

1. Prior to viewing Segment 4 of *The Case of the Technical Knockout*, discuss the previous segment to review the problem and what the tree house detectives have learned thus far. Download a copy of the **Problem Board** from the NASA SCI Files™ web site, select **Educators**, and click on the **Tools** section. The **Problem Board** can also be found in the **Problem-Solving Tools** section of the latest online investigation. Have students use it to sort the information learned so far.
2. Review the list of questions and issues that the students created prior to viewing Segment 3 and determine which, if any, were answered in the video or in the students' own research.
3. Revise and correct any misconceptions that may have occurred during Segment 3. Use tools located on the Web, as was previously mentioned in Segment 1.

4. Review the list of ideas and additional questions that were created after viewing Segment 3.
5. Read the overview for Segment 4 and have students add any questions to their lists that will help them better understand the problem.
6. **Focus Questions**—Print the questions from the web site ahead of time for students to copy into their science journals. Encourage students to take notes during the program to answer the questions. An icon will appear when the answer is near.

View Segment 4 of the Video

For optimal educational benefit, view *The Case of the Technical Knockout* in 15-minute segments and not in its entirety. If you are viewing a taped copy of the program, you may want to stop the video when the Focus Question icon appears to allow students time to answer the question.



After Viewing

1. At the end of Segment 4, lead students in a discussion of the Focus Questions for Segment 4.
2. Have students discuss and reflect on what the tree house detectives did to solve the mystery of what caused the technical glitches to occur. Ask the students what they would have done differently to solve the problem.
3. The following instructional tools located in the Educators area of the web site may aid in the discussion: Experimental Inquiry Process Flowchart and/or Scientific Method Flowchart.
4. Choose activities from the Educator Guide and web site to reinforce concepts discussed in the segment. Pinpoint areas in your curriculum that may need to be reinforced and use activities to aid student understanding in those areas.

5. Wrap up the featured online PBL investigation. Evaluate the students' or teams' final product, generated to represent the online PBL investigation. Find sample evaluation tools in the Educators area of the web site under the main menu topic **Tools** by clicking on **Instructional Tools**.

6. Have students write in their journals what they have learned about GPS, satellites, auroras, electricity, magnets, and the Earth's atmosphere so that they can share their entry with a partner or the class.

Careers

archeoastronomer
astrobiologist
astrometrist
astrophysicist
cosmologist
cultural astronomer

Resources *(additional resources located on web site)*

Books

Anawalt, Paula Bonnier: *The Crystal Palace: A Tale from the Gold Country*. Abongold Books, 2000, ISBN: 0966841409.

Canizares, Susan: *Northern Lights*. Scholastic, Inc., 1998, ISBN: 0590761552.

Kalman, Bobbie: *The Sun*. Crabtree Publishing, 2000, ISBN: 0865056927.

Love, Ann and Jane Drake: *The Kids Book of the Night Sky*. Kids Can Press, 2004, ISBN: 1553371283.

St. Antoine, Sara: *Stories from Where We Live: The Great Lakes*. Milkweed Editions, 2003, ISBN: 1571316396.

Souza, Dorothy: *Northern Lights*. Lerner Publishing Group, 1994, ISBN: 0876146299.

Tocci, Salvatore: *Experiments with the Sun and the Moon*. Scholastic Library, 2003, ISBN: 0516274694.

Waboose, Jan Bourdeau: *Skysisters*. Kids Can Press, 2002, ISBN: 1550746995.

Video

NOVA: Magnetic Storm: *Earth's Invisible Shield*
Grades 6–adult

Planet Earth: *The Solar Sea*
Grades 3–6

Schlessinger Media: *Telecommunications (The Way Things Work)*
Grades 6–adult

Web Sites

NASA: What is the Magnetosphere?

Visit this great web site to learn all about the magnetosphere and how it helps protect Earth from magnetic storms.

<http://science.nasa.gov/ssl/pad/sppb/edu/magnetosphere/>

NASA's Laboratory for Astronomy and Solar Physics Solar Flare Theory

This NASA web site spotlights solar flares, the biggest explosions in the solar system. NASA provides some general information about solar flares, a feel for scientific research into the energetic emissions from flares, and a glance into the future of solar flare research.

<http://hesperia.gsfc.nasa.gov/sftheory/index.htm>

NASA: Ask the Space Scientist

NASA astronomer Dr. Sten Odenwald addresses such topics as the Sun, solar storms, auroras, and the Earth's magnetism on this FAQ site.

<http://image.gsfc.nasa.gov/poetry/ask/askmag.html>

Space Weather

Find out what the "weather" is going to be like today in space! Get the current space weather conditions, the number of sunspots, the probability of disturbances, the aurora forecast, and much more.

<http://www.spaceweather.com/>

NASA: The Sun-Earth Connection Forum (Viewer)

On this “must visit” site for everyone, manipulate real time Sun images by zooming in and out while comparing the size of the Sun to a scale model of the Earth. There are also some great graphics to help you understand more about the internal and external workings of the Sun and how it affects our Earth. Mini video clips offer more explanations and interviews with real astronomers and scientists.

http://sunearth.gsfc.nasa.gov/sunearthday/media_viewer/flash.html

NASA: The Sun-Earth Connection Forum (Educators Area)

Visit this web site for lots of great classroom activities on everything to do with the Sun-Earth connection! Free educator guides for download.

<http://sunearth.gsfc.nasa.gov/edsecef.htm>

The Aurora Page

See beautiful pictures of auroras taken by Jan Curtis.

<http://www.geo.mtu.edu/weather/aurora/images/aurora/jan.curtis/>

Iceland Worldwide – Northern Lights

This site contains beautiful pictures of the Northern Lights as seen from Iceland.

<http://www.iww.is/art/shs/pages/thumbs.html>

NORDLYS Northern Lights

Located above the Arctic Circle in Norway, the Andoy Rocket Range in Andenes is home to the annual Northern Lights Festival that celebrates the wonder and beauty of auroras. Visit this site to see some awesome pictures of auroras, learn about auroral mythology, the science behind auroras, and real-time measurements of auroral activity.

<http://www.northern-lights.no/english/arts/nordlyst.shtml>

Activities and Worksheets

In the Guide	Sunspots Pairs	
	Use magnets to learn about sunspots and what causes solar flares and coronal mass ejections.	62
	What's the Delay?	
	Run a relay race to learn how signals travel to and from satellites.	63
	How Many Spots Does the Sun Have?	
	Plot sunspots over time to learn about the solar cycle.	65
	The Magnificent Magnetosphere	
	Create a simple paper model of the magnetosphere.	66
	Plotting the Aurora Oval	
	Plot coordinate points to pinpoint the location of the auroral oval and where to view the northern lights.	68
	Making a Magnetometer	
	Make your own magnetometer.	70
	Answer Key	
	71
On the Web	Matching Magnetic Activity	
	View some awesome images of solar activity and find the ones that match.	

Sunspot Pairs

Segment 4

Purpose

To learn how sunspots are created and that they are often in pairs

Procedure

1. Tape a bar magnet to one end of a pencil. The magnet will represent a simple sunspot pair. See diagram 1.
2. Place two books so that the space between them is just a little less than the width of the plastic box.
3. Place the plastic box on the books so that the two books support the box and there is an open space underneath the box. See diagram 2.
4. Put on goggles for eye protection.
5. Sprinkle a small number of iron filings in the box to create a thin layer. The box represents the surface of the Sun.
6. Insert the bar magnet underneath the box.
7. Observe the iron filings and the pattern that they create. You can gently tap the box to make the pattern more apparent.
8. Record your observations and illustrate the pattern. **NOTE:** *The pattern seen shows the lines of force of a classic dipole magnetic field. Sunspot pairs with magnetic fields like this one don't often produce solar flares.*
9. Tape 2–3 donut magnets to your pencil in a random arrangement. See diagram 3.
10. Shake the box to redistribute the iron filings into a thin layer again. If needed, empty the iron filings and repeat step 5.
11. Insert the donut magnets and observe. Record and illustrate your observations.

NOTE: *This magnetic field configuration on the Sun's surface might lead to a solar flare. Complicated magnetic fields store lots of energy. Think of a twisted rubber band. When it snaps back, energy is released. The same thing happens to sunspot magnetic fields. When they get twisted and tangled, they want to snap back to look like the field of a simple bipolar sunspot group. The energy that's released when a magnetic field snaps triggers a solar flare or a coronal mass ejection.*

Conclusion

1. In your own words, describe what causes a solar flare and/or coronal mass ejection.

Extension

Research solar flares and/or coronal mass ejections. Create a report, poster, model, or some other type of presentation to explain how, why, and when they occur.

Materials

small, plastic box
2 small books
iron filings
bar magnet
2–3 donut magnets
pencil
tape
science journal
goggles

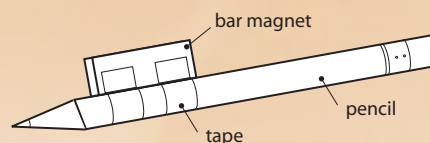


Diagram 1

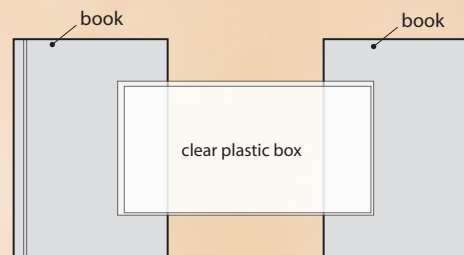


Diagram 2

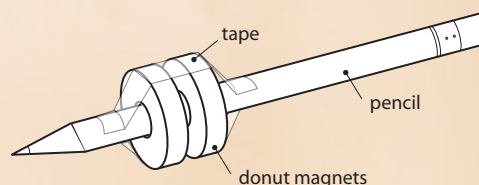


Diagram 3

What's the Delay?

Segment 4

Purpose

To understand that satellite transmission of radio waves can be delayed because of interference

Teacher Prep

Number 10 cups from 1 to 10. Number 10 cups in a different color from 1 to 10. Divide the class into two equal teams. For the relay area (large open area), place 2 pieces of tape about 3 meters apart to mark the start lines for each team. Place a small table approximately 10 meters from each start line. Put one set of cups on each table.

Materials

2 sets of 10 numbered cups
 large, open area
 2 small tables or large, flat surface

Background

Satellites use radio waves to send information to a receiver. Because it takes time for the waves to travel, there is usually some delay. The length of the delay is equal to the radio wave's travel time. GPS receivers use the travel time to determine their distance from at least four satellites, which in turn helps pinpoint their exact location on Earth. If anything causes a change in the travel time, misinformation may be transmitted.

Procedure

1. In your team, designate one person to be an astronaut at the command and control center and one person to be a satellite. The remaining team members will be "signals."
2. The satellite person needs to go to the satellite table and stand behind it.
3. The signals people will line up in a straight line behind the start line.
4. The astronaut person will stand to the left of the first signal at the start line.
5. Begin the relay race following these rules:
 - a. The objective of the relay race is to build a pyramid out of the 10 cups.
 - b. The astronaut will give a command to the first signal. He/she will carry (relay) the command to the satellite, who in turn will obey. Only one command at a time. For example, you can say, "Pick up cup number 1." But you cannot say, "Pick up cup number 1 and place it next to cup number 2." That would be two directions!
 - c. The satellite must only do exactly what the signals tell him/her to do. They cannot make a move without a command.
 - d. Once a signal has given the command, he/she returns to the end of the line to wait for a turn to carry out another command.
 - e. The astronaut may send the signals as quickly as he/she desires but only as long as they are sent one at a time. Be careful because problems may arise when the satellite receives too many signals at one time.
 - f. The team that completes the pyramid first wins.
6. After completing the relay race, play again, but this time choose one person from each team to represent interference.
7. Students representing interference will walk back and forth across the relay line and the signals will have to stop and/or go around the interference.

What's the Delay?

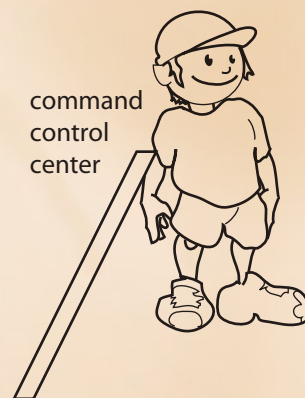
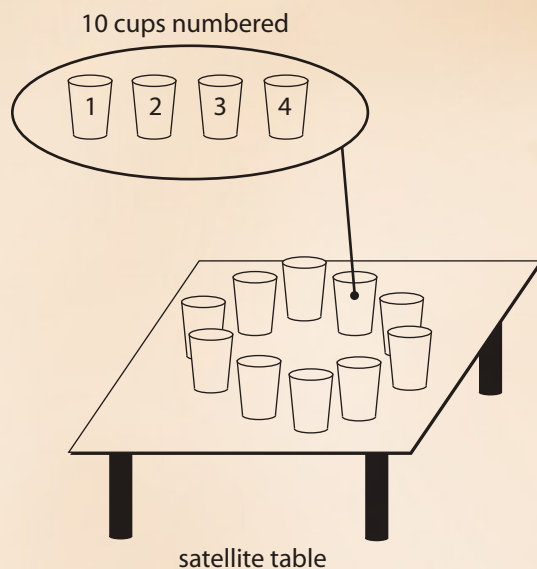
Segment 4

Conclusion

1. What problems did your team encounter with the sending and receiving of commands?
2. What would you do differently next time?
3. What would happen if you increased the distance between the astronaut and the satellite? Decreased the distance?
4. How does distance affect the signal?
5. What happened when interference interrupted the relay of signals?
6. What might cause interference with real satellite signals?
7. Describe what happened to cause the tree house detectives' technical problems.

Extension

Run the relay race again, but have the satellite build a different configuration out of the cups. Compare it with the pyramid and decide which was easier to build and why.



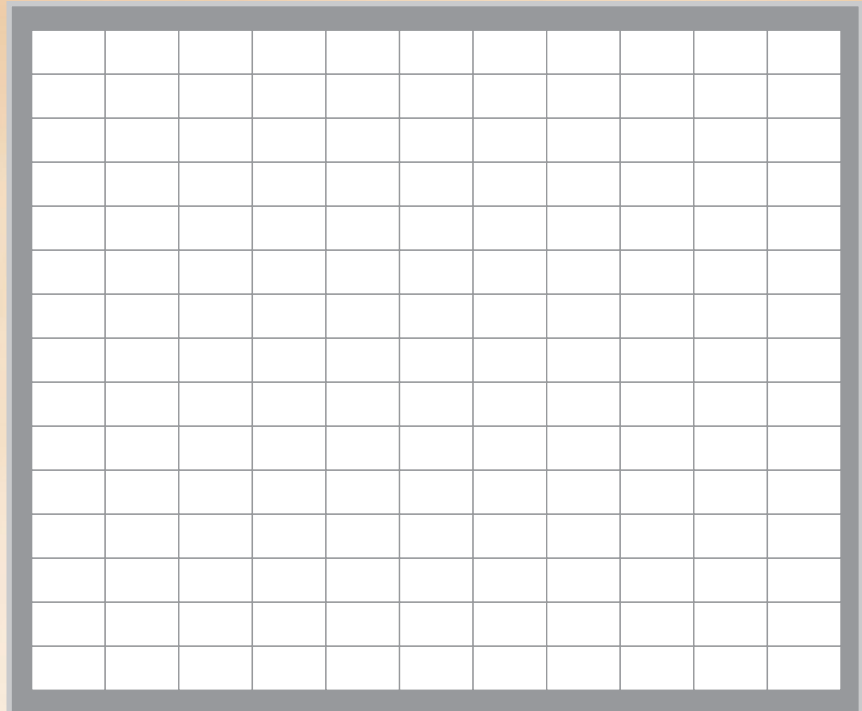
How Many Spots Does the Sun Have?

Segment 4

Astronomers have been observing and recording the number of sunspots for hundreds of years. After analyzing the data, astronomers have determined that sunspots increase and decrease over an 11-year cycle. Listed in the chart below is the number of sunspots seen in December of each year over an 11-year period.

Look at the data and graph. Determine the increment to be used on the graph for the number of sunspots and label it. Also be sure to give the graph a title and label each axis appropriately.

1991-144 sunspots
 1992-82 sunspots
 1993-48 sunspots
 1994-26 sunspots
 1995-10 sunspots
 1996-13 sunspots
 1997-41 sunspots
 1998-81 sunspots
 1999-84 sunspots
 2000-104 sunspots
 2001-132 sunspots



Answer the following questions based on the data and graph.

1. According to the data, in what year did astronomers see the most sunspots? The fewest?
2. If the number of sunspots seen follows the same pattern, what do you predict will be the number of sunspots seen in 2006? 2012?
3. As the number of sunspots increases, what do you think will happen on Earth?

The Magnificent Magnetosphere

Segment 4

Purpose

To create a simple paper model of the magnetosphere

Background

A stream of ionized gases (called a solar wind) blows outward from the Sun at about 400 km/second but varies in intensity with the amount of surface activity on the Sun. The Earth's magnetic field shields the Earth from much of the solar wind. When the solar wind encounters Earth's magnetic field, it is deflected like water around the bow of a ship. The imaginary surface at which the solar wind is first deflected is called the bow shock. The corresponding region behind the bow shock and surrounding the Earth is called the magnetosphere. It represents a region of space dominated by the Earth's magnetic field that prevents most of the solar wind from entering. However, some high-energy charged particles from the solar wind leak into the magnetosphere. These high-energy particles are trapped in the Earth's magnetic field, and as they flow back and forth along the magnetic field lines, they come down into the atmosphere near the north and south poles. As the charged particles enter the atmosphere, they collide with oxygen and nitrogen molecules. As the molecules collide, they decay from the excited states. As they decay, they emit delicate colors of light that we see in an aurora.

Materials

Magnetosphere Model
(p. 67)
scissors
colored pencils
glue or tape

Procedure

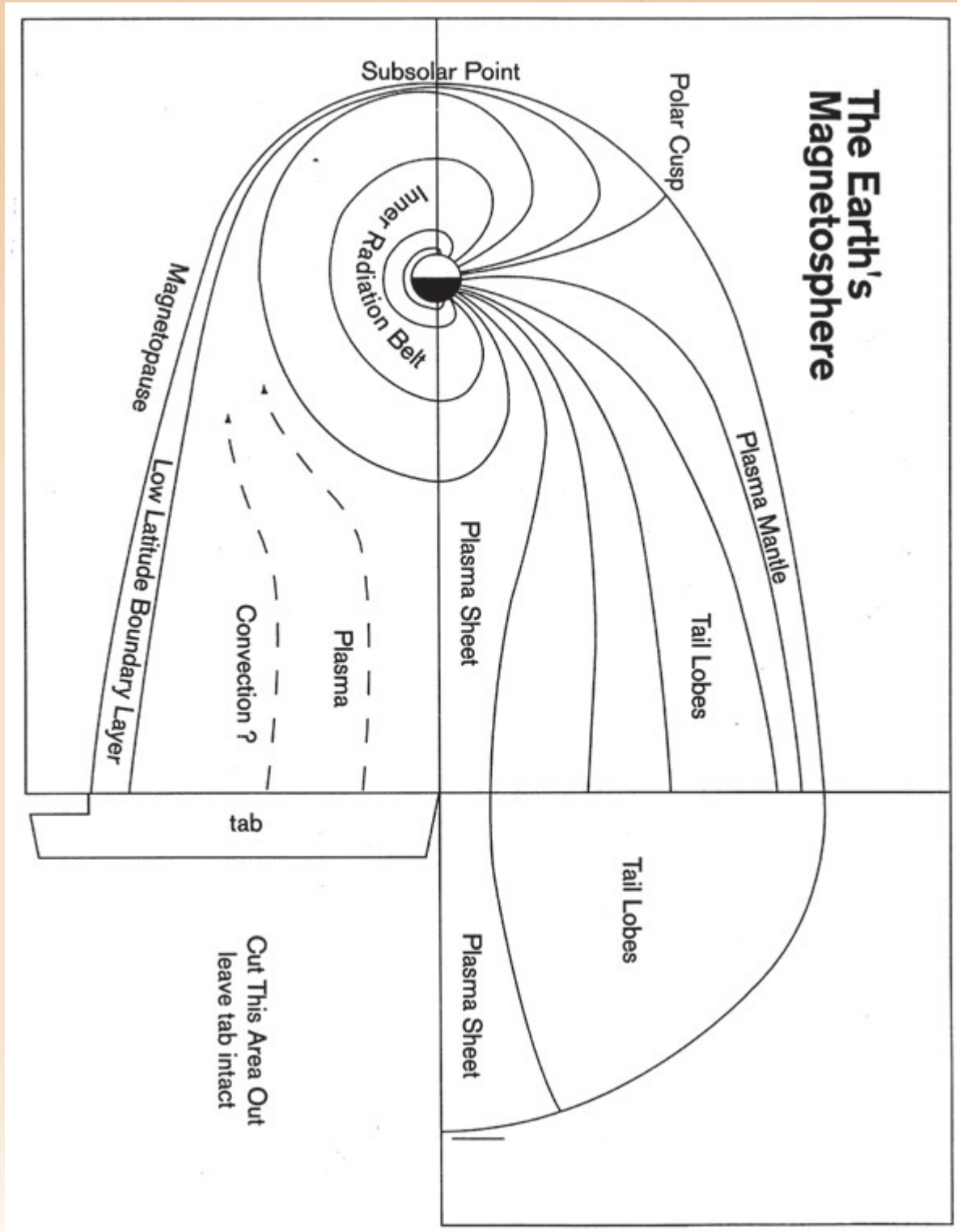
1. Color the diagram on page 67.
2. Using scissors carefully, cut along the outer edge of the diagram.
3. Fold along the main solid line that borders the tab.
4. Fold along the main solid line that intersects the Earth.
5. Glue or tape the tab in place.
6. Conduct research to learn more about the magnetopause, plasma mantle, magneto tail (tail lobes), plasma sheet, polar cusp, and inner radiation belt.

Extension

Create a three dimensional (3D) model of the Earth and the magnetosphere.

The Magnificent Magnetosphere

Segment 4



Plotting the Aurora Oval

Segment 4

Purpose

To find and plot locations on maps by using geographic coordinates

Teacher Prep

Students should have a good working knowledge of latitude and longitude. Review coordinates and how to plot points. Discuss lines of latitude and longitude by using a globe and compare how they look on a globe instead of on a flat map.

Materials

metric ruler
colored pencils
Activity Sheet (p. 69)
atlas

Background

The most spectacular example of the way that the Sun and Earth are connected is the phenomenon of the Aurora Borealis (northern lights) and the Aurora Australis (southern lights). In North America, the northern lights are seen most dramatically in only certain places over the Arctic region. This area is called an auroral oval.

Procedure

1. On the Activity Sheet, label the latitude lines. Begin at the center point (Arctic) with 90 degrees and mark each circle 10 degrees less than the previous circle. End at 30 degrees.
2. Plot the points for the outer ring of the oval.
3. Connect the points in the outer ring.
4. Plot the points for the inner ring.
5. Connect the points in the inner ring.
6. Using the grid scale (1 cm = 1400 km) measure (in km) the approximate widths of the auroral oval to determine its shortest and longest distances between the inner and outer rings.
7. Record the distances on the Activity Sheet in the spaces provided.
8. Color the oval with your favorite auroral colors.

Conclusion

1. Where would you travel in North America to see an aurora?
2. Give the approximate coordinates for the center of the auroral oval?
3. How far is the center of the auroral oval from the geographic North Pole (90 degrees North)?
4. If your location were 205 degrees, 65 degrees, in which area of the sky would you look for the aurora?

Extension

1. Read a story that describes a folktale or legend associated with auroras. Using what you have learned about magnetic field lines, the ionosphere, the magnetosphere, and so on, try to explain the "truth" while describing how the folktale might have begun.
2. Pretend your classmates are an ancient people and have just experienced an aurora. Write a story about what you saw and why. Remember that you have no scientific knowledge, so this explanation or story will be a folktale.
3. In class, tell your story to another person and ask that person to tell it to someone else, and so on, until everyone has heard the story. Have the last person tell the story to the whole class and compare it to your original story. Discuss how and why legends change through many "tellings" by many generations.



Plotting the Aurora Oval

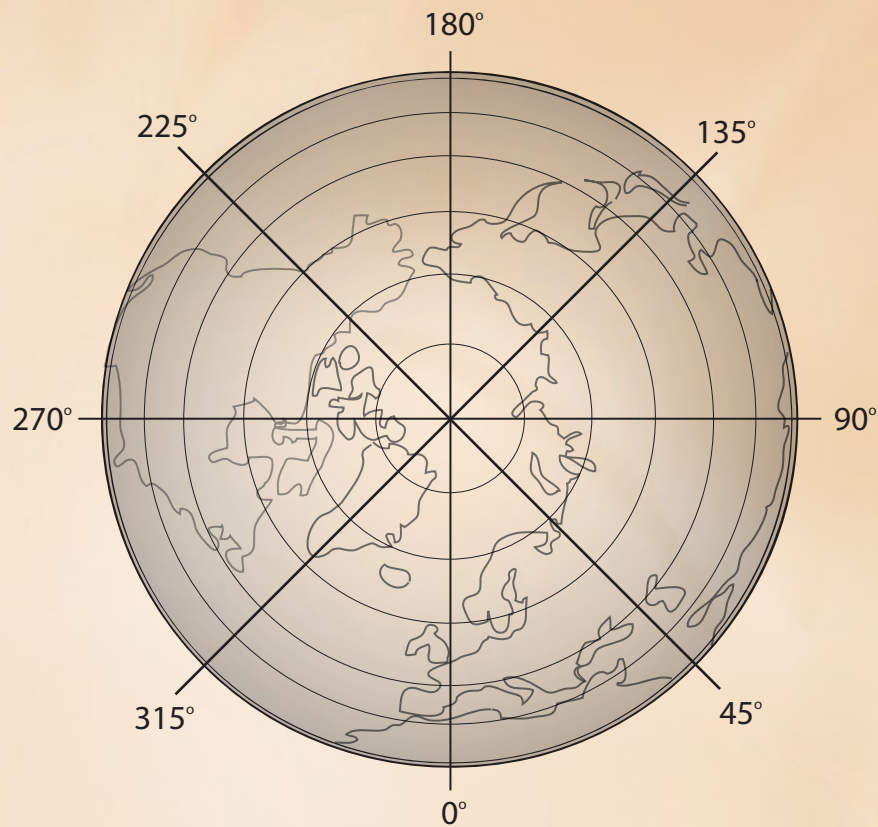
Activity Sheet

Outer Ring of Auroral Oval:

Point 1 (90,65)	Point 7 (0,60)
Point 2 (135,64)	Point 8 (320,63)
Point 3 (180,60)	Point 9 (315,60)
Point 4 (225,55)	Point 10 (300,60)
Point 5 (270,50)	Point 11 (245,50)
Point 6 (45,63)	Point 12 (200,58)

Inner Ring of Auroral Oval:

Point 1 (90,78)	Point 7 (0,75)
Point 2 (135,72)	Point 8 (320,72)
Point 3 (180,70)	Point 9 (315,70)
Point 4 (225,67)	Point 10 (300,67)
Point 5 (270,65)	Point 11 (245,62)
Point 6 (45,67)	Point 12 (200,70)



Grid Scale: 1 cm = 1400 km

Making a Magnetometer

Segment 4

Purpose

To make a simple magnetometer

Background

Magnetic field lines are invisible. We can only see the effects of the magnetic force that they exert. Magnetometers are devices used to detect and measure the strength of magnetic fields. Like compasses, magnetometers give you information about magnetic fields. A magnetometer will dip or point toward a source of magnetism.

Procedure

1. On a small piece of masking tape, stick the straight pins so that they point in opposite directions. See diagram 1.
2. Lay the sewing thread crosswise to the masking tape and pins so that it sticks to the tape. See diagram 2.
3. Thread the other end of the sewing thread through the straw.
4. Pull the thread from the top to adjust the thread so that the pins at the bottom have just enough clearance to swing freely.
5. Tape the thread in place at the top of the straw. See diagram 3.
6. Lay the tape on a flat surface with the pins facing up.
7. To magnetize the pins, stroke the pins from left to right several times with the bar magnet.
8. Pick up the straw and hold the straw so that the pins move freely.
9. Bring the north end of the bar magnet near the pins and observe what happens. If they repelled, mark that end of the tape with an "N" for north. If they were attracted to each other, mark with an "S" for south.
10. Use your magnetometer to find magnetic things in your classroom.

Conclusion

1. What magnetic items did you find in your classroom ? How did you know?

Extension

Build a more complicated magnetometer to help you study the Earth's magnetic field.
<http://image.gsfc.nasa.gov/poetry/workbook/magnet.html>

Materials

10-cm piece of plastic straw
2 straight pins
masking tape
sewing thread
bar magnet with poles marked

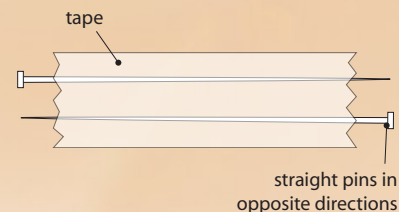


Diagram 1

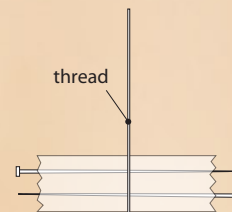


Diagram 2

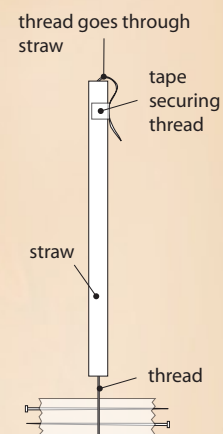


Diagram 3



Answer Key

Segment 4

Sunspot Pairs

1. Answers will vary but might include that solar flares and coronal mass ejections are created when energy is released from an entangled magnetic field.

What's the Delay?

1. Answers will vary.
2. Answers will vary.
3. If distance increases, travel time for the signal will increase. If distance decreases, travel time decreases.
4. With less travel time, the signals can be relayed faster.
5. The signals took longer to get to and from the astronaut and the satellite.
6. Answers will vary but should include that a geomagnetic storm occurred, causing disruption (delay) of the radio waves that were sending signals to the GPS receivers. The delay of the signals caused the satellites to send incorrect coordinates.
7. Answers will vary but should include that the tree house detectives were geocaching during a geomagnetic storm. The storm interacted with the ionosphere and caused a delay in the signal between the satellites and their GPS receiver. This delay gave the tree house detectives inaccurate coordinates.

How Many Spots Does the Sun Have?

1. 1991, 1995.
2. 10-15 sunspots in 2006 and 130-150 sunspots in 2012.
3. Answers will vary, but might include that there might be more geomagnetic storms causing more disruption to satellite transmissions and other electronic devices.

Plotting the Auroral Oval

1. You would travel to the northern reaches of North America such as Canada and Alaska.
2. The center of the auroral oval is located approximately at 270 degrees, 80 degrees.
3. Approximately 1200 km.
4. You would look directly up.

Making a Magnetometer

1. Answers will vary.